TMSG status

Proceedings of the Terrain Mapping SubGroup (TMSG)

- Re-activated early 2020
- as of Feb 29th 2024:
  - 65 subscriptions (+/-1)
  - 15 countries
  - ~50% with CEOS background
  - ~30% Geomorphometry.org
  - ~25-30 have actively contributed to the intercomparison exercise DEMIX (incl. industry!)
- main (only) activity still is was DEMIX
- (hybrid) DEMIX workshop & TMSG plenary scheduled for held 12/13 July 2023, supported by ESA

Subscription page: https://ec.europa.eu/eusurvey/runner/WGCV-TMSG_membership
Wednesday 12 July: DEMIX workshop

Thursday 13 July: TMSG plenary

For proceedings see the Geomorphometry23 web page: https://geomorphometry.orggeomorphometry23/
### TMSG/DEMIX@VH-RODA

<table>
<thead>
<tr>
<th>15:40 - 17:00</th>
<th>Digital Elevation Models (DEM)</th>
<th>Chair: Peter Strobl (EC-JRC) / Clement Albinet (ESA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>15:40 - 16:00</td>
<td>Results from the Digital Elevation Model Intercomparison eXercise (DEMIX) Abstract</td>
<td>Peter Strobl (EC-JRC)</td>
</tr>
<tr>
<td>16:00 - 16:20</td>
<td>Planimetric Misregistration Assessment between DEMs Abstract</td>
<td>Serge Riazanoff (Visioterra)</td>
</tr>
</tbody>
</table>

### FRM session on 28/11/2023
- Presented first concept for GCPIX

### DEM session on 29/11/2023
- Two contributions from DEMIX

For abstract and presentations see VH-RODA web site: [https://earth.esa.int/eogateway/events/vh-roda/agenda#collapseFour](https://earth.esa.int/eogateway/events/vh-roda/agenda#collapseFour)
DEMIX Results
Findings of the JRC DEM benchmarking workshop (Jan 2019):

❖ **new data sets** are coming up (“Copernicus DEM“), which might change the DEM ‘landscape’

❖ EO platforms and ‘data cubes’ make data increasingly available also at continental to global scales

❖ literature is rich in **DEM validation and comparisons** of (almost) everything with everything else in many different places

❖ methodologies vary and results are not always **representative or comparable** between studies and locations

➢ a coordinated approach is desirable!

➢ bring CEOS TMSG and the International Society for Geomorphometry (ISG) together!
DEMIX Scope

CEOS WGCV mandate for DEMIX:

- perform a state-of-the-art comparison of the major global (free & open) DEMs
- provide recommendations on best available DEM options depending on domain and area to allow informed choices

Expected Outcomes

- Consistent and comprehensive DEM definitions and terminology (t)
- Base (t) and extended (g) set of benchmarking metrics and respective algorithms (t) and open source tools (g)
- Detailed comparison results on test areas (t) and aggregated wall to wall benchmarking results (g)
- Recommendations regarding reference DEMs (t) and consistent orthoimage (g)
- Final report (t) and peer-reviewed publication (g)

(t) threshold; (g) goal
DEMIX outcome

after
- 3 years,
- 3 plenaries,
- Teams groups
- 3 subgroups, each with 5-15 active members,
- 130+ subgroup meetings, each with at least 4 participants
- a conference paper and video,
- 3 peer-reviewed publications,
- a new ‘DEMIX tiling’ system,
- a processing platform, …

we are almost there…
Revised terminology and developed comprehensive definitions (glossary)
Peer reviewed paper published, 53 citations as of 02/2024: Guth et. al. 2021

https://doi.org/10.3390/rs13183581
Preparatory and support activities

- Global master grid (‘DEMIX-tiles’) implemented
- Extensive study on influence of resampling on planimetric misregistration
- Reference DEM repository and DEMIX test tile preparation facility

Thanks for vtWeb & ESA support!
DEMIX ‘wine contest’

**Step 1**
Obtain high quality source elevation data
- Obtain and mosaic DEMs covering test area
- 6 candidate global DEMs, 1", geographic
- Source reference DTM: 1-5m UTM projection
- Source reference DSM: if available

**Step 2**
Prepare reference DEMs from the source data
- Aggregate reference DEMs to 1" spacing
- Pixel-is-point
- Pixel-is-area
- For high lat COPDEM, separate Pixel-is-point
- For high lat ALOS, separate Pixel-is-area
- Convert to WGS84/EGM2008 if needed
- Convert to ellipsoid, then to geoid
- Use grids from NGA via PROJ and national/regional mapping agency
- Use GDAL for areas in the USA

**Step 3**
Evaluate the reference and test DEMs
- Process test areas and create GIS database
- Compute test area statistics
- Create difference outputs
- Compute metrics
- Produce Evaluations table with initial tolerances

**Step 4**
Jupyter Notebook
- Rank the global DEMs
- Produce Wine Contest
  - Produce Opinions table
  - Compute confidence levels
  - Produce final rankings
  - Adjust tolerances if required
  - Filter database
  - Produce graphics

WORKFLOW

Courtesy: C. Grohman
DEMIX test area distribution

- 24 test areas, 236 DEMIX tiles (10x10km²) on four different continents with reference data
- Reference data preparation tool
- All major geomorphological landforms and landcover types represented incl. coastal areas (partial water)
- 15 different criteria in 3 classes
- Pixel by pixel comparison against reference data
- >55,000 individual test scenarios (rows in opinions database)
DEMIX test area variability

LCCS 300m (2015)

Iwahashi & Pike (2007)

Meybeck et al. (2001)

Geomorphons (2013)

Norway
Oxford
Caen
Valonne
Trentino
Vanoise
Pyrenees
Ebro Delta
Madrid
Republican River
Canyon Range
Redwoods
Shenandoah
Blackwater
Chincoteague
Almeria
State Line
Charleston
Canary East
La Palma
Pernambuco
La Reunion
São Paulo
Uruguay
DEMIX test criteria

- 3 main classes of criteria: elevation, slope, and roughness difference
- 5 different metrics to characterise difference per test area: AVD, STD, RMSE, MAE, LE90
... and the winner is:

**COPDEM**
Overall best DSM

**FABDEM**
Best DTM (except for steep terrain)

**ALOS AW3D30**
Sometimes 2nd place might be better in steep terrain than FABDEM

Courtesy: C. Grohman
Peer reviewed paper accepted: Bielski et al 2024

Final report close to release (JRC technical report)
In the meantime

- Further criteria:
  - Hillshade
  - Wetness index

- New metrics:
  - FUV (fraction unexplained variance, 1-r²)

- More test areas:
  - 107 test areas in the USA, ES, CA, BR, UY, FR, UK, NO, NL, DK
  - 1700+ tiles

Courtesy: P. Guth
Focus in on single tile

- Even though all the DEMs are compared to a reference DTM, the only DSM in the group is not the best performer.
- CopDEM family is clearly better than the others, although FABDEM has degraded CopDEM.
- ALOS is significantly worse
- NASADEM did not improve on SRTM (or change it much), and neither performs very well
- ASTER fails

<table>
<thead>
<tr>
<th>DEMIX TILE</th>
<th>N39PW113H</th>
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<tbody>
<tr>
<td>AREA</td>
<td>canyon_range</td>
</tr>
<tr>
<td>LAT</td>
<td>39.15</td>
</tr>
<tr>
<td>LONG</td>
<td>-112.35</td>
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<tr>
<td>COP</td>
<td>0.104251</td>
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<tr>
<td>TANDEM</td>
<td>0.10731</td>
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<tr>
<td>FABDEM</td>
<td>0.160949</td>
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<tr>
<td>ALOS</td>
<td>0.539178</td>
</tr>
<tr>
<td>NASA</td>
<td>0.806989</td>
</tr>
<tr>
<td>SRTM</td>
<td>0.800862</td>
</tr>
<tr>
<td>ASTER</td>
<td>0.960294</td>
</tr>
</tbody>
</table>

Courtesy: P. Guth
Up to new shores?

- Coastal areas globally are witness to growing disaster risks.
- The elevation/area around “Coastlines” are the interface between land and water (+/- 10m depth/height)
- Detailed elevation models are required to estimate tide areas (sea level rise), emergency (tsunami), environment (e.g. loss of biodiversity), inhabitants impact (e.g. urban development)
- Objective: to {create/test} a global coastal elevation dataset/{method}
Community recommendation from the key forums “VH-RODA” and “JACIE”

Build up a **GCP DB for the VHR domain**

CEOS WGCV welcomed and closely followed the **Sentinel-2 Global Reference Image (GRI)** and harmonization with **Landsat GCP Library** which can serve as a **reference for high resolution (HR)** sensors (around 10 m – 50m GSD)
CEOS is now proposing the development of a harmonised global CEOS Ground Control Points (GCP) Database and its extension to cover also VHR Optical Data [2.5-10m GSD, and potentially <2.5m GSD]

CEOS agencies are pooling activities and resources towards a unified and harmonized CEOS GCP Database for HR&VHR Optical Data

**GCPIX!**


**Check out S. Saunier’s poster!**

Used by the USGS for improving the Landsat GCP, by ESA for GRI

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National mosaic - 10m georeferenced image

UTM zone mosaics - 2.5m georeferenced images

Ground Control Point spatial database

Ground Control Point ancillary data (photographs, site sketches and image chips)

Absolute geometric accuracy for the product is 5.6m CEP90 ALOS image chips, field photographs and site sketches
GCPIX – first outline

❖ **Key elements to be further developed during GCPIX**

- define **criteria** for the **suitability** of GCPs (by resolution, season, wavelength, ...) and respective uncertainties, spatial density and distribution requirements
- establish **protocols and formats for documenting and sharing** GCPs and respective libraries
- **harmonization** of existing **sources** from the different CEOS agencies **towards a unified DB**
- identification of **gaps/weaknesses** in coverage, consistency, quality, availability, ...
- design and set-up of a **(cloud-based) platform** for sharing and managing the database
- **improvement, densification**, and allocation of **additional source data (VHR)**
- potential inclusion of **DEM data/reference chips** from suitable and agreed reference data
Exkursion:
CEOS Common Terminology
In-situ disambiguation

- **In-situ / Ex-situ**
  - Observed in its original location vs brought back to laboratory for testing

- **In-situ / satellite**
  - Observed e.g. ground-based, sea- or airborne vs from an orbiting platform

- **In-situ / remote**
  - Observed close to the location of the sample vs from a (significant) distance

Various communities use the term 'in-situ' in different ways – in contrast to different alternatives.

It is very important to be clear about which notion of ‘in-situ’ is referred to. Sometimes it relates more to location and sometimes to fidelity.
Paper methodology

- Review of 12 existing vocabularies / terminologies
  - Assessment of useability
  - Identification of circular definitions and inconsistencies
  - Assessment of structure

- Review of ISO guidelines on ‘information and documentation: thesauri and interoperability with other vocabularies) ISO 25964

- Presentations to CEOS, ESA and WMO meetings

- Detailed study of some sample terms
  - Observation, in-situ, interoperability
  - As examples of broader problems

- Building a hierarchical set of base and core terms
Problems found

❖ Simple lists of words are not used often – structure is important
❖ Rare to have versioning (or keep older definitions) – and definitions change
❖ Very large number of definitions for some terms – e.g. in ISO online browsing platform
❖ Inconsistent definitions (e.g. in-situ, observation, sample, …)
❖ Superficial definitions (e.g. interoperability) lacking full framework
❖ Circular definitions – and poor use of the foundational ‘base terms’
❖ Development process – isolated efforts – creates these problems
Lost in translation: The need for common vocabularies and an interoperable thesaurus in Earth sciences

P.A. Strobl¹, E.R. Woolliams² and K. Molch³
¹JRC, ²NPL, ³DLR

❖ First draft (July 2023) reviewed by 12 expert individuals (thank you)
  • Very significant changes made based on their responses
❖ Final draft submitted to Surveys in Geophysics (December 2023)
❖ Currently waiting for peer reviewer comments
❖ Pre-print available at : (TBC)
Executive Summary

❖ Completed work to explore a CEOS common online dictionary (CEOS WGCV Action Item 49-06, 06/2021)
❖ Results summarized in a publication – preprint pending
❖ Main Findings
  ▪ Large interest in the topic; need, urgency, and effort are recognized
  ▪ Many good but isolated dictionaries exist
  ▪ Critical: Fundamental terms often defined inconsistently
❖ Implementation needs a coordinated effort endorsed by all stakeholders
❖ CEOS with its Interoperability Framework could be a suitable body to put this in place
Thank you!

Big thanks to all active volunteers:

In particular the sub-group leaders:

Peter Guth, Carlos Grohman, Carlos Bielski, Serge Riazanoff, Conrad Bielski, Serge Riazanoff, and Carlos López Vázquez, the wine contest mastermind.

as well as ESA (Clement Albinet) and USGS (Dean Gesch) for their support!

any questions?

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